# FINAL REPORT

**South Carolina State Wildlife Grant SC-T-F13AF01185**
South Carolina Department of Natural Resources
October 1, 2013 – September 30, 2015

Project Title: ASSESSING THE STATUS OF MACGILLIVRAY'S SEASIDE SPARROWS *AMMODRAMUS MARITIMUS MACGILLIVRAII* IN SOUTH CAROLINA

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## Objective 1: Survey tidal marsh habitat to improve understanding of the breeding distribution of MacGillivray's Seaside Sparrow in South Carolina.

Accomplishments:

*Introduction*: Our objective was to survey South Carolina tidal marshes to determine the range and abundance of breeding MacGillivray's Seaside Sparrows as effectively as possible given limitations of time, expense and personnel. We chose to take a two-pronged approach, surveying both randomly selected marshes and historically occupied marshes and in 2014, some marshes known to be winter hotspots for Seaside Sparrows (see objective 3 below). We performed 5 minute listening surveys at 127 survey points overall (90 in randomly selected marshes) in 2014 and 2015, using methods that allowed comparisons with other Seaside Sparrows surveys along the Atlantic coast of the US.

*Methods:* We chose survey points with a two-stage process. We first chose marshes to survey, including both marshes that were historically occupied by breeding Seaside Sparrows and marshes chosen randomly. Historically occupied marshes were chosen after consulting relevant publications (Cely 2003) and after correspondence with birders, managers, and a search of the archives of the Carolinabirds email list. We surveyed three historical marshes—Tom Yawkey Wildlife Center, Santee Coastal Reserve, Cape Romain NWR—in 2014 and re-surveyed the first two of those in 2015. Randomly chosen marshes were selected by randomly choosing hexagons from a previously defined grid of 40km$^2$ hexagons (available for download at http://www.tidalmarshbirds.net/?page_id=1595) covering all areas with tidal marshes in South Carolina. We chose seven random hexagons to survey in 2014 and added nine more in 2015.

Within each chosen historical marsh or randomly chosen hexagon, we chose multiple survey points by inspection of aerial imagery to be 1) in suitable habitat, 2) accessible on foot or by boat, and 3) separated by 500m from the nearest other survey point. To allow a surveyor to cover two different marshes in a morning, we generally chose between 5 and 7 survey points in each marsh (occasionally only 3 if tidal marsh habitat was limited or up to 11 if other factors meant we could only survey that one marsh in a morning). Marshes surveyed are shown in Fig. 1, and survey points and their locations are listed in Table 1.

We surveyed each point three times between late April and late June. (A few points got only two surveys because when we were limited by weather, tides or other.) Our survey windows in 2014 were 17 April-1 May, 8-19 May, and 26 May-6 June. In 2015 our survey windows were 30 April-12 May, 21-30 May, and 14-24 June. We conducted 5 minute listening surveys to facilitate comparisons to data from multispecies marsh bird surveys being conducted by others in the northeastern US (Wiest 2015) and by other investigators in South Carolina (Roach 2015), Georgia (E. Hunter pers. comm.), and Florida (A. Schwartzer pers. comm.). At each marsh, we would travel to survey points between sunup and 11:00 a.m. At each survey point we listened and watched, recording each Seaside Sparrow heard or seen and its distance in each of the 5 minutes of the listening period, while recording presence or absence of other marsh bird species and also weather, tide state, and ambient noise. Once each season at each point we recorded habitat in a 50m circle around each survey point, noting the proportion of the circle composed of low marsh, high marsh, salt marsh terrestrial border, brackish terrestrial border, invasives, pannes-pools-and-creeks, open water, upland, and wrack. We noted the number of snags present, noted dominant species of vegetation and their percent cover, measured the inclination and azimuth of the horizon at six points, and photographed each site.

Because we have evidence that surveys conducted in April and the first week of May were sometimes contaminated with detections of singing migrants and lingering winter visitants (Laskaris and Hill, manuscript in prep.), we will rely on data from May 8 and later (our second and third round of surveys each year). We consider a survey point as occupied if sparrows were detected on at least one visit in our second or third survey window. This definition of occupancy is both biologically meaningful and useful for comparison with surveys done elsewhere. We also measure overall detection rate, defined as the proportion of surveys with at least one detection of a sparrow. Detection rate is generally lower than occupancy rate (because a single detection defines a point as occupied even if other surveys at that point don't detect any birds). We also track the number of individuals detected per survey as a third measure of abundance.

*Results*: At historically occupied sites (Fig. 2), we surveyed 22 points in three marshes in 2014 and 17 points in two marshes in 2015. We found consistently high occupancy at Tom Yawkey Wildlife Center: 8 of 13 points were occupied in 2014 and 10 of 10 points in 2015. Occupancy at Santee Coastal Reserve was 3 of 7 points in 2014 and 4 of 7 in 2015, while we detected no sparrows at 3 Cape Romain NWR points in 2014 (and did not resurvey in 2015). Overall, 64% of points were occupied, and we detected sparrows on 36 of 76 surveys, for a detection rate of 47% at historically occupied sites.

Detections at randomly chosen tidal marshes were much lower (Fig. 3). We surveyed seven randomly chosen hexagons in 2014 and nine in 2015 with a total of 90 survey points across those 16 marshes. Eleven of those 90 points were occupied (12%) and unlike at historically occupied sites, we never detected sparrows at a point more than once, so with 11 detections in 170 surveys, the detection rate was 6.5%.

Although it combines data collected under slightly different conditions, we include a map (Fig. 4) that shows results from all of our random, historical and wintering sites along with a set of surveys conducted by N. Roach of Clemson University in 2014 along 9-point tidal marsh routes (largest circles in the figure). The Roach/Clemson routes were each surveyed once during the relevant time window in 2014.

*Discussion*: The scope of this project did not allow a comprehensive survey of all suitable habitat in South Carolina, but a fairly clear picture emerged, especially when our data are compared with data gathered by similar methods in other states: MacGillivray's Seaside Sparrows may be widespread in South Carolina marshes but they are very scarce except in a few "colonies."

MacGillivray's Seaside Sparrows nest in considerable density at several discrete sites in South Carolina. The site included in our surveys that fits that description is Tom Yawkey Wildlife Center, where almost all points surveyed were occupied by sparrows, and where we detected sparrows on the majority of surveys, and we detected on average 1.7 individuals per 5 minute survey. (See objective 4 below for more detail about nesting populations at that site.) Although it was not included in our survey effort, in June 2015 we visited a site on Headquarters Island on the Stono River (32.75 N 80.02 W) where William Post has conducted several studies (Hill and Post 2005; Post and Greenlaw 2009), and we found similarly dense concentrations of nesting sparrows in a small area there. A third site at ACE Basin NWR reportedly has had a high nesting density in most years (M. Purcell, L. Hartis pers. comm.) and was visited briefly in 2014, but the habitat had been altered by a very recent burn and at the time only a few Seaside Sparrows were present. There may be other similar "colonies" of nesting sparrrows yet to be documented in the state, but the patchy breeding distribution in the state has been recognized since nearly a century ago when the first nesting colony was discovered near Rantowles, SC (Sprunt 1924). Will Post (pers. comm.) has hypothesized that the Headquarters Island colony may indeed be the "descendent" of the original Rantowles colony, just having moved 7.6 miles downstream in the intervening 80 years.

Away from these few sites, however, nesting Seaside Sparrows in South Carolina were only found at very low density. Typically, even at points considered occupied, sparrows were detected only on a single survey. This was true of all 11 occupied randomly-selected points: two surveys were conducted at each point, only one of which detected any sparrows. Only a single individual was seen or heard at 8 of those 11 points (2, 2, and 3 at the remaining 3 points). Overall, across all our surveys at random points, 0.08 individuals were detected per 5 minute survey. If seaside sparrows were at all 11 occupied points for the entire breeding season, but at such low density that they were only detected once, that suggests that sparrows may have been present but not detected at some of the other sites we surveyed.

The apparent low occupancy and low density of MacGillivray's Seaside Sparrows in South Carolina tidal marshes contrasts with what has been found in nearly concurrent surveys by Elizabeth Hunter in Georgia (2013-2015) and Amy Schwarzer in northeast Florida (2014-2015). Methods of choosing sites were slightly different in those states: in Florida, Schwarzer (pers. comm.) was able to cover nearly all the marshes in the targeted stretch of coast. In Georgia, Hunter (pers. comm.) chose points along routes selected to optimize several gradients (e.g. salinity, elevation, distance to upland). However, despite the different methods of choosing points, the resulting distribution of sampled points appears reasonably similar. Occupancy on 63 points north of the St. Johns River (the southern limit of breeding Seaside Sparrows) in Florida in 2015 was about 50%, with 1-6 individuals (average 3.1) recorded per visit at occupied points. Occupancy in several hundred Georgia points was 40-50%, with densities comparable to or greater than those seen in Florida (E. Hunter, pers. comm.). If our methods truly are comparable, a possible explanation is that the core of the breeding range of MacGillivray's Seaside Sparrow is in Georgia and into northeast Florida, and that South Carolina, nearer the edge of the range, supports only patchy populations. A comparable scenario is true for subspecies *A. m. maritimus*. In Delaware, Weist (Wiest and Shriver 2015) found sparrows at essentially every survey point with estimated densities between 6 and 10 individuals per point. Seaside Sparrows seem to be widespread and common throughout New Jersey and Delaware marshes, but in Connecticut and Rhode Island near the edge of the range of *A. m. maritimus*, they are patchy and local and completely absent from many marshes (Benoit and Askins 2002; Berry et al. 2015; Wiest 2015; Wiest and Shriver 2015). To test the hypothesis that north of Georgia MacGillivray's Seaside Sparrow is a very local and patchy breeder it would be desirable to compare our data with surveys done in North Carolina, but we have not been able to obtain any North Carolina results with which to compare.

Significant deviations: None

**Objective 2: Construct a model connecting occupancy by breeding MacGillivray's Seaside Sparrows to habitat variables.**

Accomplishments:

*Introduction:* On-the-ground surveying is currently the only effective way to evaluate site suitability for MacGillivray's Seaside Sparrows. It was our goal to discern a relationship between sparrow presence and remotely sensed habitat-related variables that would allow remote evaluation of unsurveyed sites.

*Methods*: See under "Objective 1" above for survey methods. We used the results from surveys at 90 systematically chosen points in 16 randomly chosen marshes (Figure 1, hexagons). We used four remotely sensed habitat characteristics that we thought would most influence sparrow occupancy or detection: % landcover type, % saline & brackish wetland, elevation, and distance to upland edge. We added a fifth habitat measure from data we took in the field at survey points: vegetation community composition. Percent landcover type was taken from the 2011 National Landcover Database (Homer et al. 2015). Percent landcover was calculated for a 200m buffer surrounding each survey point. Percent saline (E2EM1N) & brackish (E2EM1P) wetlands were calculated from data retrieved by the National Wetland Inventory produced by the USFWS (US Fish And Wildlife Service 2007). We calculated the total acreage of the two wetland habitat types in a 200m buffer surrounding each survey point. The relative proportions of the two wetland types were used as a proxy for salinity. The mean elevation of the 200m buffer around each survey point was measured using coastal LiDAR elevation datasets produced by NOAA & the SC Dept. of Natural Resources. Distance to upland edge was also measured from each survey point. Finally, the percent composition of several vegetation communities within 50m of each survey point was calculated from our field data.

*Results*: Seaside sparrow detection was compiled for sites surveyed on the 2$^{nd}$ and 3$^{rd}$ survey windows of 2014 and 2015, with the 1$^{st}$ survey window being excluded as there was a high likelihood that Seaside Sparrows detected during this window were late-season migrants (Laskaris and Hill, manuscript in prep.). During 170 surveys in 2014 and 2015, we detected MacGillivray's Seaside Sparrows at 11 of our 90 randomly selected survey points. We found no significant correlations between the 5 habitat variables and detections.

*Discussion*: Although the limited number of survey points (90) and low level of occupancy (12%) left us with little power to find subtle habitat relationships, it is perhaps worth noting that other more detailed studies have also failed to predict density of nesting (Gjerdrum et al. 2008) or wintering (Trinkle 2013) Seaside Sparrows from habitat measurements. Whatever it is that guides their distribution, we are so far rather poor at predicting it remotely, and this small study did not make any significant advances.

Significant deviations: None.

**Objective 3: Determine whether marshes occupied in winter by Seaside Sparrows are also used for breeding by the same sparrows.**

<u>Accomplishments</u>:

*Introduction.* In the Carolinas, little has been published on MacGillvray's Seaside Sparrow breeding ecology since a series of papers more than 70 years ago, soon after nesting in South Carolina was first documented (Sprunt 1924, 1926, 1927; Tomkins 1941). In contrast to this lack of recent information on breeding sparrows, wintering ecology of Seaside Sparrows in the region has been documented by a series of banding-based studies (Michaelis 2009; Shaw 2012; Winder and Emslie 2012; Winder et al. 2012; Trinkle 2013), which have shown that concentrations of sparrows winter reliably in the same areas year after year, with individuals showing very high site fidelity. However, since their plumages differ only subtly (Fig. 5), there is no reliable way to distinguish winter visitants of the northern subspecies of Seaside Sparrow (*A. m. maritimus*) from year-round resident *A. m macgillivraii*.

We targeted areas of known winter concentrations (marshes with local wintering populations of more than 50 individuals) for breeding season surveys, using methods as in objective 1 above. We chose three sites with five survey points each: one site near the Kiawah Island Bridge (32.6N, 80.0W), one at Little River Inlet (33.85N, 78.57W), and at North Inlet (33.33N, 79.19W). The Little River Inlet points fell within a hexagon chosen at random for sampling (see objective 1 above). We counted data from those 5 points for both "winter" and "random" sampling.

*Results:* As described in Objectives 1 and 2 above, we used only data from the second and third round of surveys in each year due to concerns about lingering wintering or migrant birds through the first week of May. In 2014 Seaside Sparrows were detected on 2 of 29 surveys at wintering sites, giving an occupancy rate of 13%, and a detection rate of 7% (Fig. 6). These figures were not distinguishable from those at random marshes, which had 12% occupancy and 6.5% detection rates. We find no evidence that prime Seaside Sparrow wintering sites also serve as preferred breeding sites for MacGillivray's Seaside Sparrows.

*Discussion:* This conclusion matches conclusions drawn by Sprunt (1926) who hypothesized that in South Carolina, Seaside Sparrows generally don't winter where they breed, and don't breed where they winter. Evidence from plumage differences (Fig. 5) and preliminary stable isotope data (C. Hill & A. Given, unpublished) indicates that wintering birds in South Carolina are a mix of northern visitants and southern MacGillivray's, but likely dominated by northern birds. Although MacGillivray's Seaside Sparrows are often referred to as a "resident" race (Post and Greenlaw 2009), this study and other winter observations at breeding marshes at the Yawkey Center (C. Hill unpublished) indicate that breeding birds seldom winter where they breed. It is an open question where and how far MacGillivray's Seaside Sparrows do move in winter. There is one record in South Carolina of a breeding bird banded at Headquarters Island on the Stono River (32.75N, 80.02W) being recaptured in winter on James Island (32.73N, 79.98W), 3.6 miles downriver in the same Stono River tidal marshes (W. Post pers. comm.). That record suggests some breeding MacGillivray's may move short distances towards the coast in winter, but aside from that bird, there is very little evidence about winter movements in MacGillivray's.

<u>Significant deviations:</u> None.

**Objective 4: Identify and closely monitor one breeding site to measure density and nest success of breeding MacGillivray's Seaside Sparrows.**

*Introduction:* Our goal was to monitor one breeding population for the breeding season, systematically banding sparrows to measure population density and sex ratio, searching for nests, tracking incubation behavior and recording nest fates to determine nesting success, and monitoring singing behavior to determine if the number of birds present was correlated to the volume of song recorded. We also monitored rodent predator presence by a capture-mark-release method.

*Methods*: Our intensive survey and demographic study were conducted from late April to mid-July 2015 at Tom Yawkey Wildlife Center Heritage Preserve in Georgetown, South Carolina. The marshes at the Yawkey Center were chosen for our demographic study as they showed relatively high densities of breeding MacGillivray's Seaside Sparrow compared to other sites during 2014 surveys, with 8 of 13 survey points occupied. We established three study plots at the Yawkey Center. Plots were placed in areas of suitable nesting habitat, determined by aerial photography, NWI datasets, previous surveys, and ground-truthing. We chose sites for the three plots representative of the variety of marsh habitats where seaside sparrow are likely to breed, encompassing marsh habitats with differing vegetation assemblages, vegetation heights, and flooding regimes.

Our three study plots, Causeway, Miller Canal, and Twin Sisters Pond (Fig. 7), were each approximately 7 hectares in size. Our first plot, Causeway, was mainly comprised of thick stands of black needlerush (*Juncus roemerianus*). A causeway built on the southern edge of this plot blocks tidal flow, which occasionally leads to waterlogging. Our second plot, Miller Canal, was comprised of short-form smooth cordgrass (*Spartina alterniflora*) with interspersed large stands of black needlerush. Miller Canal is situated in marsh with unrestricted tidal flow and large, deep creeks. Our third plot, at Twin Sisters Pond, was an impounded section of marsh with a few to several inches of standing water, and is comprised of a mixture of tall and short-form smooth cordgrass, saltgrass (*Distichlis spicata*) and small stands of black needlerush.

We systematically captured and banded MacGillivray's Seaside Sparrows at each plot. To ensure that sampling effort was distributed evenly across all plots, we divided each plot into 4 subplots, and mist-netted each subplot twice over the course of the field season on a rotational schedule, which allowed for each plot to be mist-netted a total of 8 times. Banding occurred during the early morning hours from sunrise to 10:00am. Captured birds were fitted with a USFWS aluminum leg band and three plastic color bands to facilitate identification of individuals by sight and to match banded birds to nests. Banded birds were resighted during subsequent visits to plots. We estimated sparrow populations on each plot with Lincoln-Peterson mark recapture methods.

Nest searching began in early May, and each plot was searched for nests every 3-4 days. Nests were monitored until chicks had fledged or until the nest failed. For failed nests, we determined cause of failure when possible. Nest vegetation composition was measured in a 1m$^2$ area around each nest and compared to random 1m$^2$ vegetation samples (n=67) taken within each plot. Nest measurements taken included nest height, nest vegetation composition, nest vegetation height, nest visibility (% cover), and nest canopy. Additionally, we monitored incubation behavior of nesting females using iButton temperature data loggers placed inside the nest cups of nests with full clutches or chicks. From iButton temperature records, we calculated the number of trips taken off the nest (frequency of off-bouts), length of time off the nest (duration of off-bouts), and mean nest temperature. We estimated daily nest survival probability using the Mayfield Method (Mayfield 1975) and a nest survival model that includes more parameters, McEstimate (Etterson 2011).

We performed weekly counts of singing male seaside sparrows at each of our 3 plots from 5/12/15 to 7/1/2015. Male songs were counted for a five minute period between sunrise and 11:00AM.

We trapped and marked marsh rice rats (*Oryzomus palustris*) at each of the plots. Half of each plot (3.5ha) was set with 32 evenly spaced Sherman small mammal traps. Traps were set during three trapping windows, approximately 2 weeks apart, from late May to late June.

*Results*: Across all plots, we found a total of 36 nests, banded 183 individuals, and had 29 re-sights. Although we found 36 nests, we found them at all stages from laying and incubation through the chick phase, and found recently fledged chicks on the plots from nests we had not found, indicating that many nests went undiscovered on the plots. Our lowest density plot had an estimated 5 birds/ha compared to our highest density plot which had roughly 13 times more birds, with an estimated 68 birds/ha. The same trend was seen for each measure of sparrow abundance in all our plots, with Causeway holding the lowest numbers, Miller Canal holding intermediate numbers, and Twin Sisters holding the greatest numbers (Fig 8). Across all plots, 46% of all banded birds were adult males, 28% were adult females, and 26% were chicks or fledgelings.

Nest heights differed between plots, with mean nest heights of 42 cm at Causeway, 22 cm at Miller Canal, and 33 cm at Twin Sisters (Fig. 9). Nest heights were highly correlated with the mean vegetation height at each plot. The mean nest height across all plots was 31 +/-8.6 cm (s.d.). Nest sites (Table 3) had on average 9.2% more smooth cordgrass, 15.8% more saltgrass, 24% less black needlerush and similar amount of open mud/water compared to random vegetation plots. Though the standard error for each of these measures is quite large, there is a trend for seaside sparrows to nest in areas with less black needlerush, and in areas with proportionally higher amounts of smooth cordgrass and salt grass.

Nest success was highest at Twin Sisters and Causeway, with 52% and 50% of found nests fledging, respectively, compared to Miller Canal at 14% nest success (Table 3). Overall nest success was around 44% for found nests. Productivity was 1.18 chicks fledged/ found nest, which is near productivity estimates of 1.06 found in Massachusetts (Marshall & Reinert 1990), but is much lower than productivity estimates of 3.10 found on the Gulf coast in Mississippi (Lehmicke et al. 2013).

The rate of trapping success for marsh rice rats was 7.3% (Table 4), although the second round of trapping experienced a dramatic drop in catch rate compared to the first and third trapping windows, possibly due to lower marsh rice rat activity during the higher tides which occurred during the second round. Unfortunately, we had no recaptures of marked rats and were unable to estimate densities within each plot. Our raw capture rates showed no significant differences across plots.

We recorded an average of 83 ± 32 (s.d.) songs in each 5 minute listening period, and there was no difference in song output between the three plots ($F_{(2,22)} = 0.343$, $P = 0.71$) – song levels do not reflect the varying bird densities shown by other measures. Although on any given survey, song output might be from 20% to 100% of the maximum recorded at a site, there was no obvious seasonal decline in song or other trend (Fig. 10).

We estimated survival for all nests which were observed as active more than once (n=30). For 16 failed nests and 222 observation days, we determined that Mayfield daily nest survival was 92.8%.

Using McEstimate (Etterson 2011), we measured the daily survival for all nests as 93.1% (+/- .06). The model which best explained nest survival or failure indicated that nest height, nest age, and the nest height*age interaction were the most important predictors of nest fate. Daily nest mortality, at 6.9%, was lower than daily nest mortality rates found in FL (19.4%), but higher than nest mortality rates in NY (3.3%) (Post et al. 1983).

Daily survival rates allow calculation of the effect of unfound nests on our measures of fledging success. If daily survival is constant at 93.1%, each nest, if found when initiated, would be expected to have a 40% chance of surviving to hatch and 25% chance of surviving to fledge. The fledging rate of found nests, at 45% is elevated due to the difficulty of finding nests, and because we were likely to find nests later in the nest cycle and miss nests which may have failed early on in the nesting cycle (Fig 11).

Estimated Federal Cost: $19,580 (amount spent this year 10/1/14 – 9/30/15); $34,713 total

Recommendations: Close the grant.

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**Table 1, sites surveyed for MacGillivray's Seaside Sparrows. Class 1 = randomly chosen marshes, 2 = wintering sites, 3 = historically occupied sites.**

| Site | Class | Hexagon | Point ID | Lat | Long |
|---|---|---|---|---|---|
| Ashley River | 1 | 113904 | ASHLEY01 | 32.83974 | -79.9868 |
| Ashley River | 1 | 113904 | ASHLEY02 | 32.83899 | -79.99244 |
| Ashley River | 1 | 113904 | ASHLEY03 | 32.83624 | -79.99902 |
| Ashley River | 1 | 113904 | ASHLEY05 | 32.83034 | -80.01407 |
| Ashley River | 1 | 113904 | ASHLEY06 | 32.82583 | -80.01935 |
| Ashley River | 1 | 113904 | ASHLEY07new | 32.84102 | -80.03699 |
| Ashley River | 1 | 113904 | ASHLEY08 | 32.83862 | -80.04117 |
| Bennett's Point | 1 | 284462 | BENPOINT01new | 32.60886 | -80.48257 |
| Bennett's Point | 1 | 284462 | BENPOINT02new | 32.60314 | -80.48575 |
| Bennett's Point | 1 | 284462 | BENPOINT03 | 32.60424 | -80.49486 |
| Bennett's Point | 1 | 284462 | BENPOINT04 | 32.60252 | -80.50458 |
| Bennett's Point | 1 | 284462 | BENPOINT05new | 32.59512 | -80.49649 |
| Bennett's Point | 1 | 284462 | BENPOINT06new | 32.58506 | -80.49628 |
| Bohicket | 1 | 115082 | Bohicket01 | 32.63054 | -80.16475 |
| Bohicket | 1 | 115082 | Bohicket02 | 32.63631 | -80.16268 |
| Bohicket | 1 | 115082 | Bohicket03 | 32.64093 | -80.15928 |
| Bohicket | 1 | 115082 | Bohicket04 | 32.64468 | -80.15541 |
| Bohicket | 1 | 115082 | Bohicket05 | 32.65198 | -80.14889 |
| Bohicket | 1 | 115082 | Bohicket06 | 32.65768 | -80.14237 |
| Bohicket | 1 | 115082 | Bohicket07 | 32.662 | -80.13793 |
| Bull Island | 1 | 280539 | Bull01 | 32.89392 | -79.63524 |
| Bull Island | 1 | 280539 | Bull02 | 32.89921 | -79.63242 |
| Bull Island | 1 | 280539 | Bull03 | 32.90475 | -79.63268 |
| Bull Island | 1 | 280539 | Bull04 | 32.91161 | -79.62881 |
| Bull Island | 1 | 280539 | Bull05 | 32.91879 | -79.6308 |
| Bull Island | 1 | 280539 | Bull06 | 32.91129 | -79.62058 |
| Combahee | 1 | 284461 | Combahee01 | 32.64518 | -80.65904 |
| Combahee | 1 | 284461 | Combahee02 | 32.64105 | -80.65752 |
| Combahee | 1 | 284461 | Combahee03 | 32.63517 | -80.65779 |
| Combahee | 1 | 284461 | Combahee04 | 32.63334 | -80.66302 |
| Combahee | 1 | 284461 | Combahee05 | 32.62977 | -80.65787 |
| Combahee | 1 | 284461 | Combahee06 | 32.62593 | -80.65266 |
| Coosawhatchie | 1 | 116255 | COOSAWHA01 | 32.58438 | -80.92349 |
| Coosawhatchie | 1 | 116255 | COOSAWHA02 | 32.58158 | -80.91893 |
| Coosawhatchie | 1 | 116255 | COOSAWHA03 | 32.57714 | -80.91802 |
| Dahwoo R. | 1 | 284070 | JEHOSSEE01new | 32.63785 | -80.34954 |
| Dahwoo R. | 1 | 284070 | JEHOSSEE02 | 32.64765 | -80.34802 |
| Dahwoo R. | 1 | 284070 | JEHOSSEE03 | 32.6455 | -80.35779 |
| Dahwoo R. | 1 | 284070 | JEHOSSEE04new | 32.64735 | -80.36816 |
| Dahwoo R. | 1 | 284070 | JEHOSSEE05new | 32.6575 | -80.37251 |

| | | | | | |
|---|---|---|---|---|---|
| Dahwoo R. | 1 | 284070 | JEHOSSEE06 | 32.65419 | -80.3801 |
| Dahwoo R. | 1 | 284070 | JEHOSSEE07new | 32.65515 | -80.38804 |
| Dahwoo R. | 1 | 284070 | JEHOSSEE08 | 32.64946 | -80.3855 |
| Mt. Pleasant | 1 | 282502 | Mt.Pleasant01 | 32.79553 | -79.81308 |
| Mt. Pleasant | 1 | 282502 | Mt.Pleasant02 | 32.79826 | -79.81741 |
| Mt. Pleasant | 1 | 282502 | Mt.Pleasant03 | 32.80443 | -79.82026 |
| Mt. Pleasant | 1 | 282502 | Mt.Pleasant05 | 32.8048 | -79.81367 |
| Mt. Pleasant | 1 | 282502 | Mt.Pleasant08 | 32.81366 | -79.7888 |
| Mt. Pleasant | 1 | 282502 | Mt.Pleasant09 | 32.80953 | -79.79222 |
| Murrells Inlet | 1 | 277005 | MUINLET01 | 33.54873 | -79.04104 |
| Murrells Inlet | 1 | 277005 | MUINLET02 | 33.55364 | -79.03484 |
| Murrells Inlet | 1 | 277005 | MUINLET03 | 33.55483 | -79.02868 |
| Murrells Inlet | 1 | 277005 | MUINLET04 | 33.58248 | -78.99679 |
| Murrells Inlet | 1 | 277005 | MUINLET05 | 33.57829 | -79.00095 |
| Pawleys | 1 | 109194 | PAWLEYS01 | 33.43264 | -79.12306 |
| Pawleys | 1 | 109194 | PAWLEYS02 | 33.43974 | -79.11785 |
| Pawleys | 1 | 109194 | PAWLEYS03 | 33.4246 | -79.12817 |
| Raccoon Key | 1 | 112336 | RaccoonKey03 | 33.01753 | -79.47704 |
| Raccoon Key | 1 | 112336 | RaccoonKey04 | 33.01921 | -79.46761 |
| Raccoon Key | 1 | 112336 | RaccoonKey05 | 33.01545 | -79.4688 |
| Raccoon Key | 1 | 112336 | RaccoonKey06 | 33.01344 | -79.47169 |
| Raccoon Key | 1 | 112336 | RaccoonKey07 | 33.02131 | -79.47256 |
| Ridgeland | 1 | 117042 | Ridgeland01 | 32.44663 | -80.88067 |
| Ridgeland | 1 | 117042 | Ridgeland02 | 32.44204 | -80.87352 |
| Ridgeland | 1 | 117042 | Ridgeland03 | 32.43781 | -80.8683 |
| Ridgeland | 1 | 117042 | Ridgeland04 | 32.43556 | -80.85266 |
| Ridgeland | 1 | 117042 | Ridgeland05 | 32.42515 | -80.84813 |
| Sheldon | 1 | 284853 | Sheldon01 | 32.59866 | -80.77857 |
| Sheldon | 1 | 284853 | Sheldon02 | 32.59485 | -80.78098 |
| Sheldon | 1 | 284853 | Sheldon03 | 32.58778 | -80.78192 |
| Sheldon | 1 | 284853 | Sheldon04 | 32.58236 | -80.78112 |
| Sheldon | 1 | 284853 | Sheldon05 | 32.5804 | -80.77466 |
| Sheldon | 1 | 284853 | Sheldon06 | 32.57186 | -80.76545 |
| Sheldon | 1 | 284853 | Sheldon07 | 32.56317 | -80.7659 |
| Tibwin | 1 | 280539 | Tibwin01 | 33.06502 | -79.50896 |
| Tibwin | 1 | 280539 | Tibwin02 | 33.05976 | -79.5109 |
| Tibwin | 1 | 280539 | Tibwin03 | 33.05932 | -79.50237 |
| Tibwin | 1 | 280539 | Tibwin04 | 33.06146 | -79.49797 |
| Tibwin | 1 | 280539 | Tibwin05 | 33.06395 | -79.49314 |
| Tibwin | 1 | 280539 | Tibwin06 | 33.06555 | -79.48745 |
| Wando | 1 | 113119 | Wando01 | 32.92126 | -79.8319 |
| Wando | 1 | 113119 | Wando02 | 32.91441 | -79.83261 |
| Wando | 1 | 113119 | Wando03 | 32.90226 | -79.84382 |
| Wando | 1 | 113119 | Wando04 | 32.89823 | -79.84757 |

| | | | | | |
|---|---|---|---|---|---|
| Wando | 1 | 113119 | Wando05 | 32.89589 | -79.85569 |
| Little River Inlet | 1,2 | 274650 | LRINLET01 | 33.85241 | -78.58532 |
| Little River Inlet | 1,2 | 274650 | LRINLET02 | 33.85276 | -78.57953 |
| Little River Inlet | 1,2 | 274650 | LRINLET03new | 33.85818 | -78.58067 |
| Little River Inlet | 1,2 | 274650 | LRINLET04new | 33.8538 | -78.57195 |
| Little River Inlet | 1,2 | 274650 | LRINLET05 | 33.85937 | -78.57387 |
| Kiawah | 2 | na | KIAWAH01new | 32.60334 | -80.12653 |
| Kiawah | 2 | na | KIAWAH02 | 32.60075 | -80.13047 |
| Kiawah | 2 | na | KIAWAH03 | 32.6057 | -80.13181 |
| Kiawah | 2 | na | KIAWAH04 | 32.63107 | -80.03634 |
| Kiawah | 2 | na | KIAWAH05 | 32.63295 | -80.03128 |
| North Inlet | 2 | na | N.INLET01 | 33.34204 | -79.18068 |
| North Inlet | 2 | na | N.INLET02 | 33.33999 | -79.1856 |
| North Inlet | 2 | na | N.INLET03 | 33.33794 | -79.19026 |
| North Inlet | 2 | na | N.INLET04new | 33.33462 | -79.19356 |
| North Inlet | 2 | na | N.INLET05new | 33.33177 | -79.19901 |
| Cape Romain | 3 | na | CR01 | 33.08192 | -79.39432 |
| Cape Romain | 3 | na | CR02 | 33.07235 | -79.3782 |
| Cape Romain | 3 | na | CR03 | 33.08145 | -79.37129 |
| Santee Coastal | 3 | na | SESPSCR01 | 33.14395 | -79.35423 |
| Santee Coastal | 3 | na | SESPSCR02 | 33.1374 | -79.35049 |
| Santee Coastal | 3 | na | SESPSCR03 | 33.13287 | -79.34401 |
| Santee Coastal | 3 | na | SESPSCR04 | 33.13922 | -79.33486 |
| Santee Coastal | 3 | na | SESPSCR05 | 33.14308 | -79.3253 |
| Santee Coastal | 3 | na | SESPSCR06 | 33.14876 | -79.33162 |
| Santee Coastal | 3 | na | SESPSCR07 | 33.15093 | -79.34659 |
| Yawkey Center | 3 | na | SESPTYWC01 | 33.2434 | -79.2219 |
| Yawkey Center | 3 | na | SESPTYWC02 | 33.23669 | -79.22555 |
| Yawkey Center | 3 | na | SESPTYWC03 | 33.23101 | -79.22166 |
| Yawkey Center | 3 | na | SESPTYWC04 | 33.22935 | -79.21346 |
| Yawkey Center | 3 | na | SESPTYWC05 | 33.21653 | -79.20652 |
| Yawkey Center | 3 | na | SESPTYWC07 | 33.1993 | -79.20534 |
| Yawkey Center | 3 | na | SESPTYWC08new | 33.20205 | -79.21163 |
| Yawkey Center | 3 | na | SESPTYWC09new | 33.19719 | -79.2133 |
| Yawkey Center | 3 | na | SESPTYWC10new | 33.19069 | -79.2178 |
| Yawkey Center | 3 | na | SESPTYWC11new | 33.18467 | -79.2301 |
| Yawkey Center | 3 | na | SESPTYWC12 | 33.17254 | -79.23698 |
| Yawkey Center | 3 | na | SESPTYWC13 | 33.17816 | -79.23363 |
| Yawkey Center | 3 | na | SESPTYWC16 | 33.17397 | -79.23126 |
| Yawkey Center | 3 | na | SESPTYWC17 | 33.18603 | -79.23069 |
| Yawkey Center | 3 | na | SESPTYWC18 | 33.20297 | -79.21363 |
| Yawkey Center | 3 | na | SESPTYWC20 | 33.23071 | -79.21238 |
| Yawkey Center | 3 | na | SESPTYWC21 | 33.22844 | -79.2225 |

**Table 2, Vegetation composition: percent coverage (± s.d.) at nests versus random plots.**

| Nests (n =37) | *S. Alterniflora* | *D. spicata* | *J. roemerianus* | Open mud/water |
|---|---|---|---|---|
| Causeway | 0 | 0 | 100 | 0 |
| Miller Canal | 58.8 +/- 21.2% | 0 | 22.5 (+/- 31.5% | 18.7 +/- 20.5% |
| Twin Sisters | 73.0 +/- 22.4% | 26.3 +/- 23.0% | 0.4 +/- 1.9% | 0.3 +/- 1.9% |
| All Plots | 66.0 +/- 27.2% | 19.2 +/-22.8% | 10.5 +/- 27.4% | 4.3 +/- 12.0% |
| **Random (n =67)** | *S. Alterniflora* | *D. spicata* | *J. roemerianus* | Open mud/water |
| Causeway | 14.8 +/- 27.8% | 0 | 81.5 +/- 35.5% | 3.7 +/- 9.6% |
| Miller Canal | 59.8 +/- 41.4% | 0 | 30.5 +/- 45.8% | 9.7 +/- 14.6% |
| Twin Sisters | 85.7 +/- 27.1% | 8.5 +/- 20.3% | 2.6 +/- 13.5% | 3.2 +/- 8.0% |
| All Plots | 56.8 +/- 43.4% | 3.4 +/- 13.4% | 34.5 +/- 46.2% | 5.3 +/- 11.0% |

**Table 3, Summary of nest fates, by plot.**

| | Fledged | Unknown | Failed (Depredated) | Failed (Marsh Wren) | Failed (unknown) |
|---|---|---|---|---|---|
| Causeway | 1 (50%) | - | - | - | 1 (50%) |
| Miller Canal | 1 (14.3) | 1 (14.3%) | 4 (57.1) | - | 1 (14.3%) |
| Twin Sisters | 14 (51.9%) | 1 (3.7%) | 5 (18.5%) | 1 (3.7%) | 7 (25.9%) |
| All Plots | 16 (44.4%) | 2 (5.6%)* | 9 (25%) | 1 (2.8%) | 8 (22.2%)** |

* The fate of 2 nests is marked as unknown as these nests were not monitored to time of fledge or fail.
** Of 8 nests which had unknown failure, 2 are suspected to have been depredated based on the timing of nest failure recorded by nest temperature data-loggers.

**Table 4, Marsh Rice Rat Trap Success**

| By Round | Catches | Empty | Visits | False Triggers | Recatches |
|---|---|---|---|---|---|
| Round 1 (5/29/15 - 6/4/15) | 7 (7.3%) | 85 (88.5%) | 4 (4.2%) | 0 | 0 |
| Round 2 (6/13/15 - 6/15/15) | 1 (1.0%) | 90 (93.8%) | 5 (5.2%) | 0 | 0 |
| Round 3 (6/26/15 - 6/29/15) | 13 (13.6%) | 68 (70.8%) | 14 (14.6%) | 1 (1.0%) | 0 |
| All Rounds | 21 (7.3%) | 243 (84.4%) | 23 (8.0%) | 1 (0.3%) | 0 |
| By Plot | Catches | Empty | Visits | False Triggers | Recatches |
| Causeway | 6 (6.3%) | 83 (86.4%) | 6 (6.3%) | 1 (1.0%) | 0 |
| Miller Canal | 9 (9.4%) | 71 (74.0%) | 16 (16.6%) | 0 | 0 |
| Twin Sisters | 6 (6.3%) | 89 (92.7%) | 1 (1.0%) | 0 | 0 |
| Plot Average | 7 (7.3%) | 81 (84.4%) | 7.7 (7.9%) | 0.3 (0.3%) | 0 |

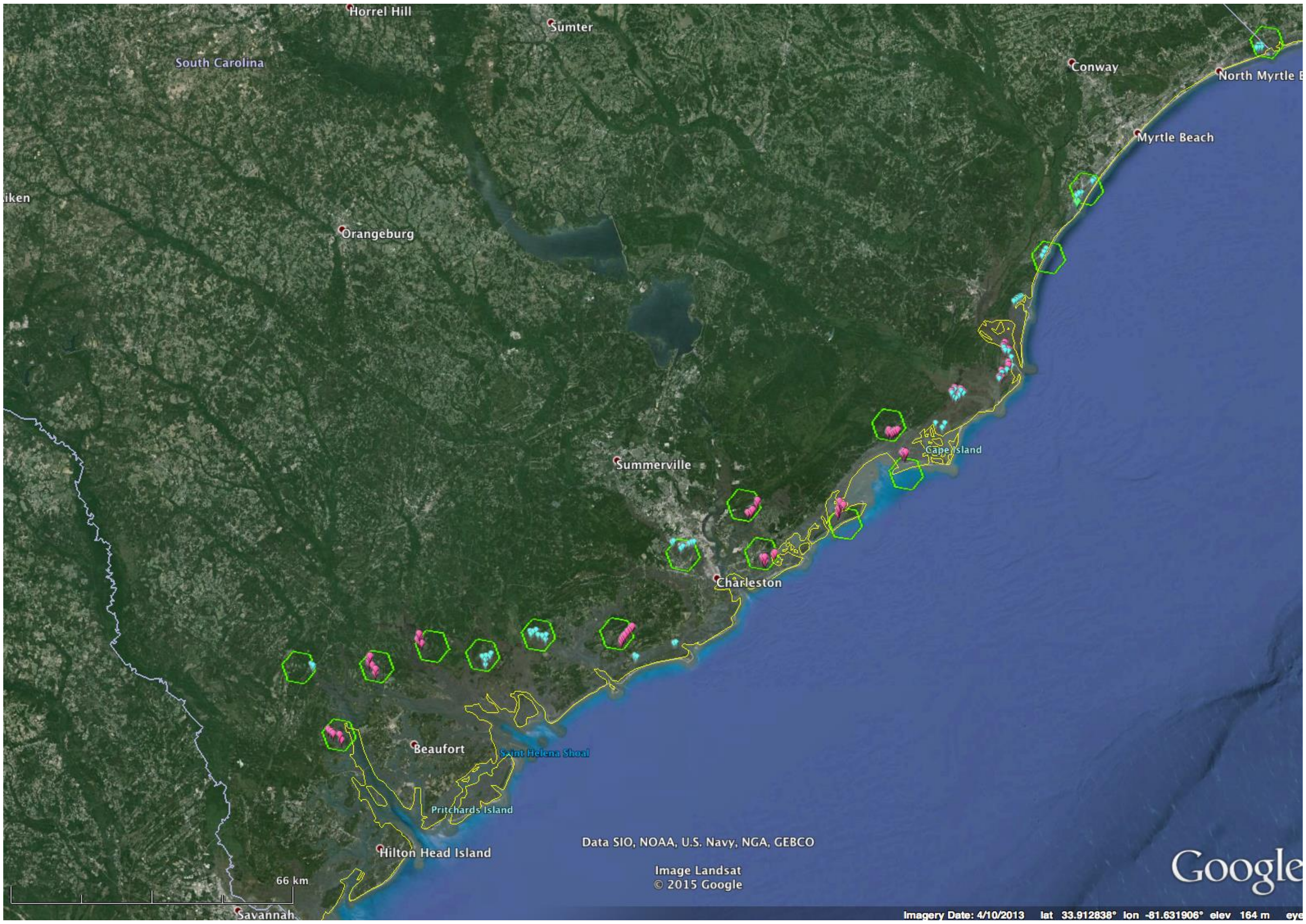


Figure 1: The coast of South Carolina, showing sites where we surveyed for MacGillivray's Seaside Sparrows. Points surveyed in 2014 are marked in blue, those surveyed in 2015 in pink. Green hexagons mark marshes chosen randomly, while historically occupied sites on the mid-north coast (bicolored points) and wintering sites at Kiawah and North Inlet (blue points) are not associated with hexagons.

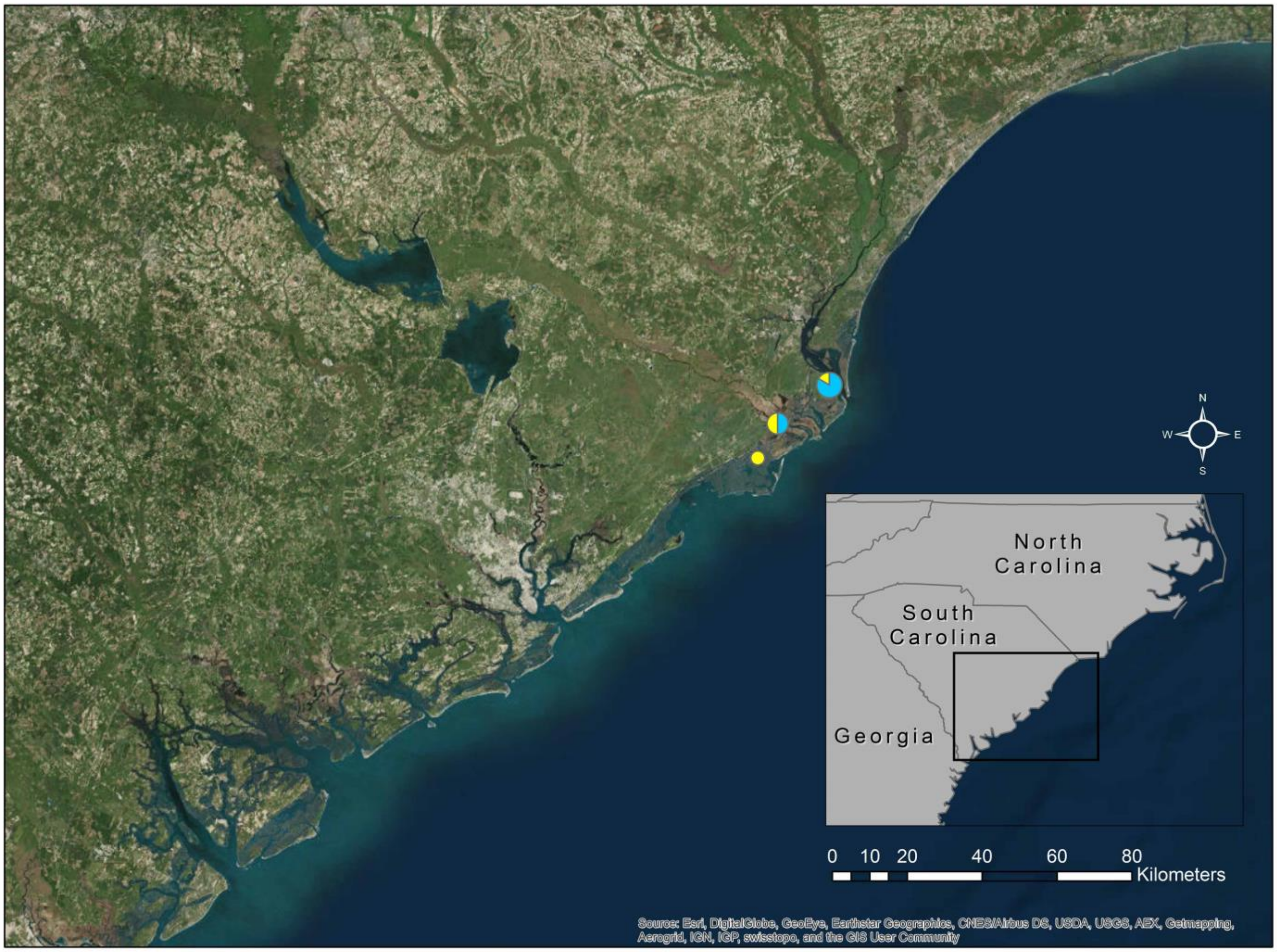


Figure 2: The coast of South Carolina, showing results of Seaside Sparrow Surveys at historically occupied sites (left to right: Cape Romain NWR, Santee Coastal Reserve, Tom Yawkey Wildlife Center). Blue shading in each circle indicates the proportion of surveyed sites that were occupied. Circles scaled to the number of points surveyed.

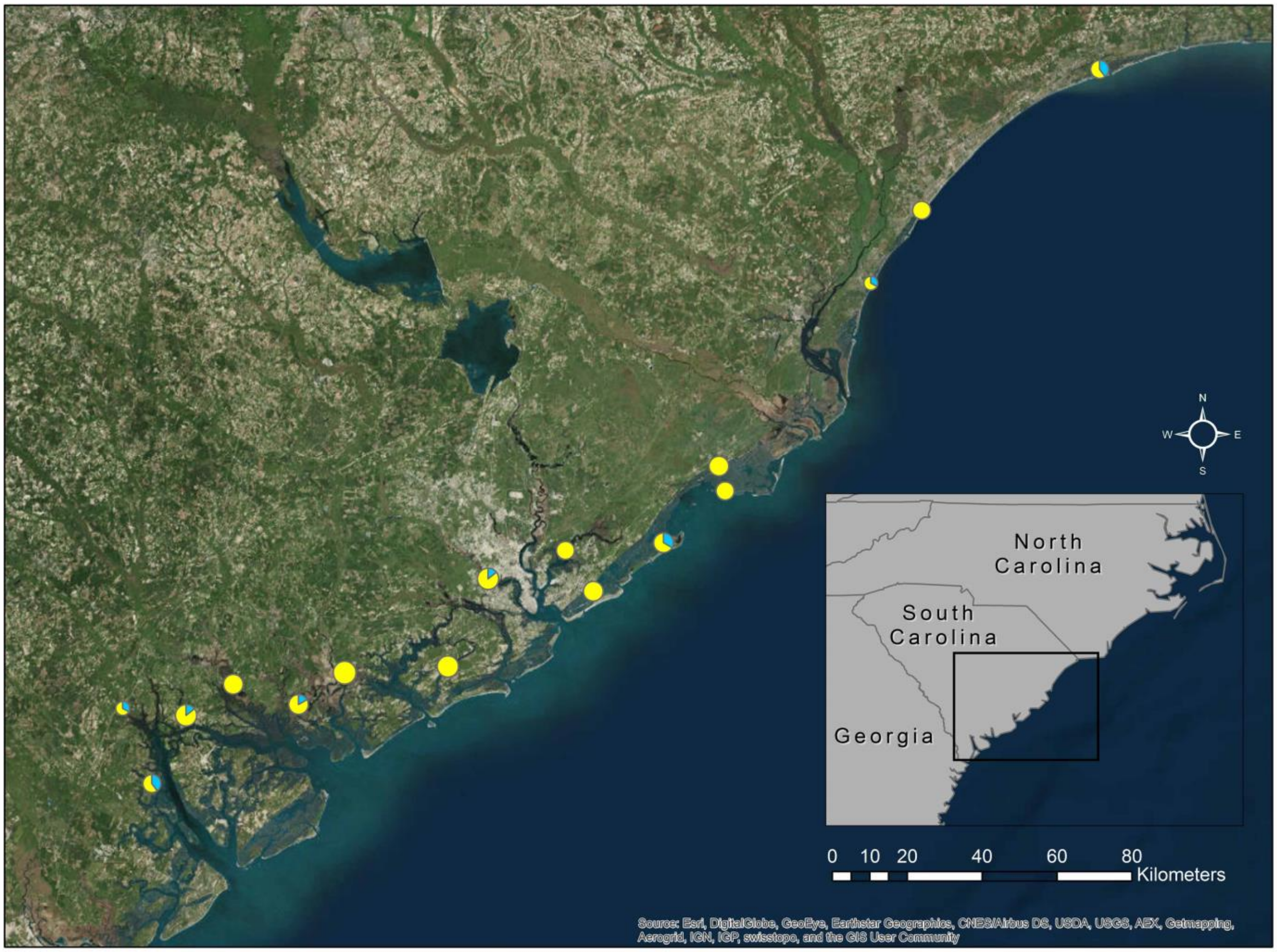


Figure 3: The coast of South Carolina, showing results of Seaside Sparrow Surveys at randomly chosen sites Blue shading in each circle indicates the proportion of surveyed sites that were occupied. Circles scaled to the number of points surveyed.

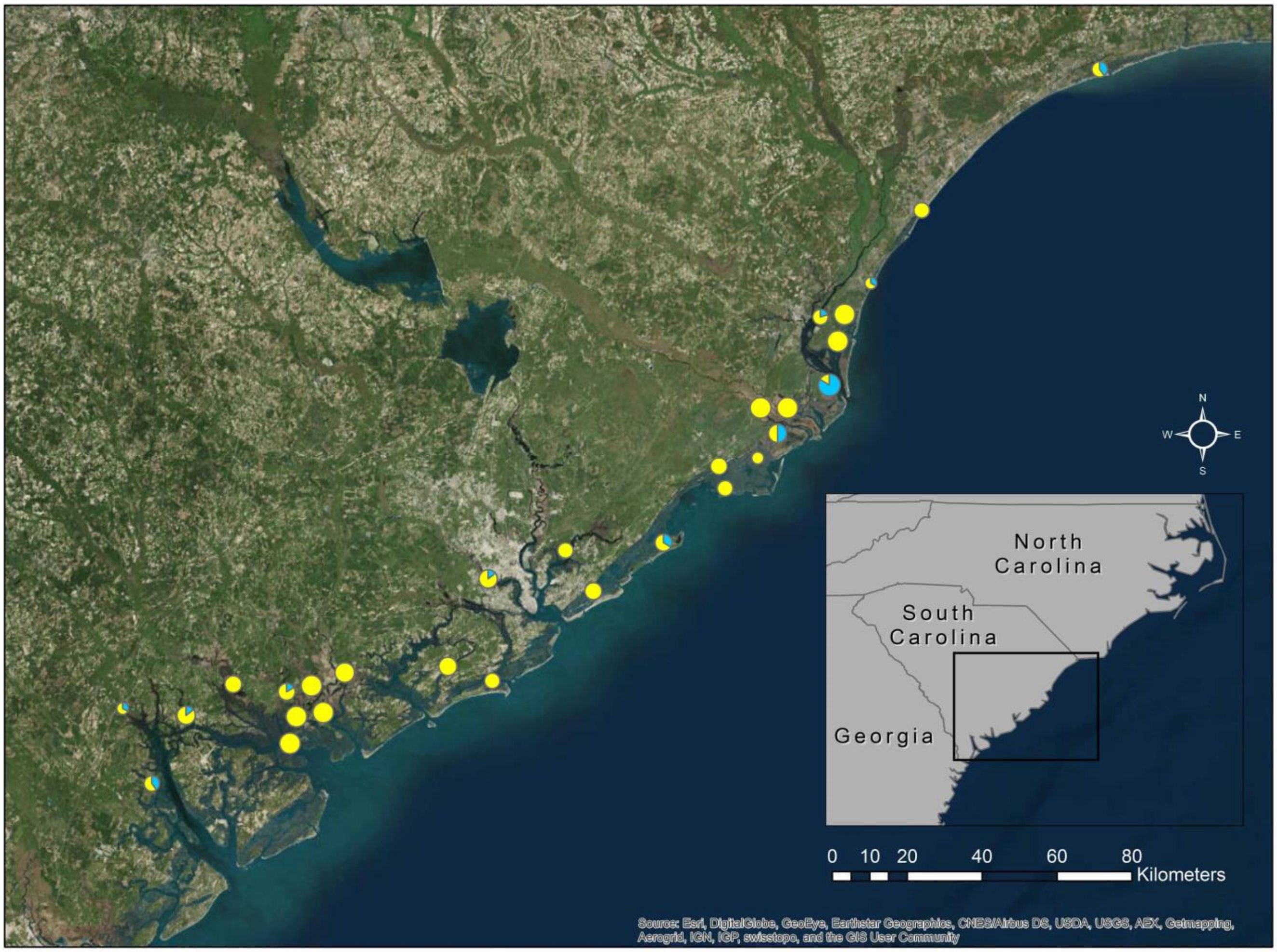


Figure 4: The coast of South Carolina, showing results of all Seaside Sparrow Surveys (historical, random and wintering sites) surveyed during 2014 and 2015 for this project as well as Seaside Sparrow detections by N. Roach of Clemson University during 2014 marsh bird surveys. Blue shading in each circle indicates the proportion of surveyed sites that were occupied. Circles scaled to the number of points surveyed, but scaling is smaller on this map than on other maps. Routes close together may not plot at the exact location (the circles can only pack so close).

Figure 5: Seaside Sparrows in fresh fall plumage, , showing subtle plumage differences betweeen slightly paler putative *Ammodramus maritimus maritimus* on left and slightly darker putative *A. m. macgillivraii* on the right.  Scott Hartley photo November 2015.

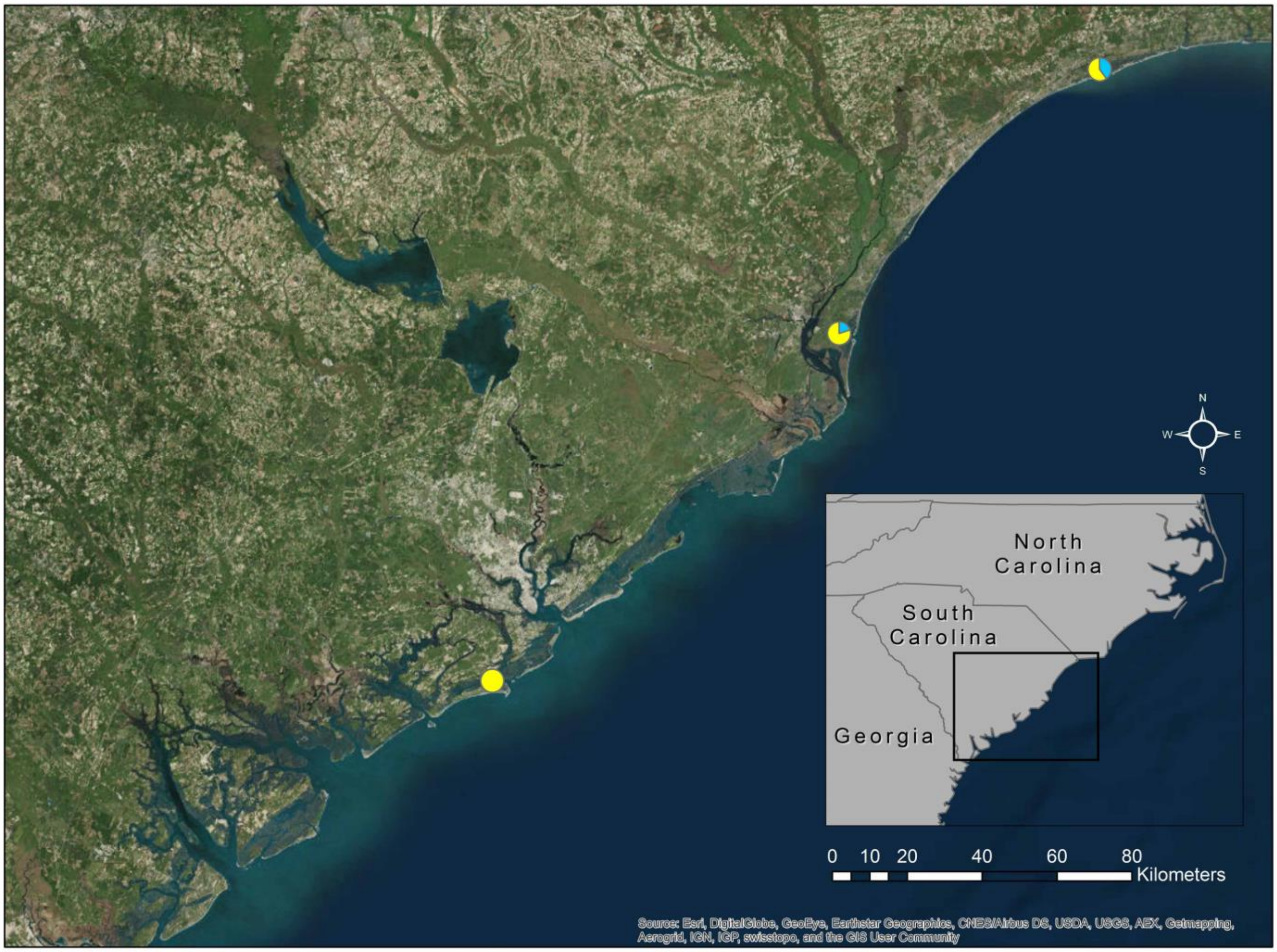


Figure 6: The coast of South Carolina, showing results of Seaside Sparrow Surveys at sites that have large densities of wintering Seaside Sparrows. From left to right, Kiawah Island, North Inlet, Waties Island. Blue shading in each circle indicates the proportion of surveyed sites that were occupied. Circles scaled to the number of points surveyed.


Figure 7: Location of three 7 ha plots used to study nesting MacGillivray's Seaside Sparrows at Tom Yawkey Wildlife Center Heritage Preserve in Georgetown, South Carolina.

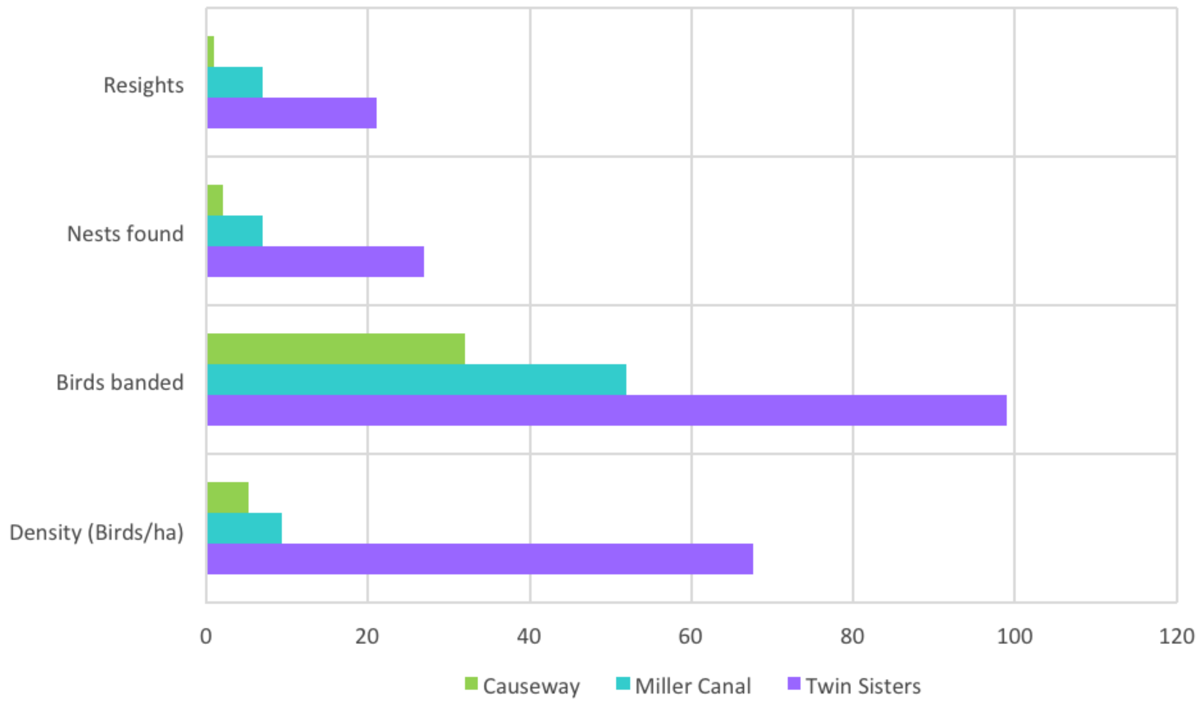


Figure 8: Four measures of Seaside Sparrow abundance at three study plots near Georgetown, SC.

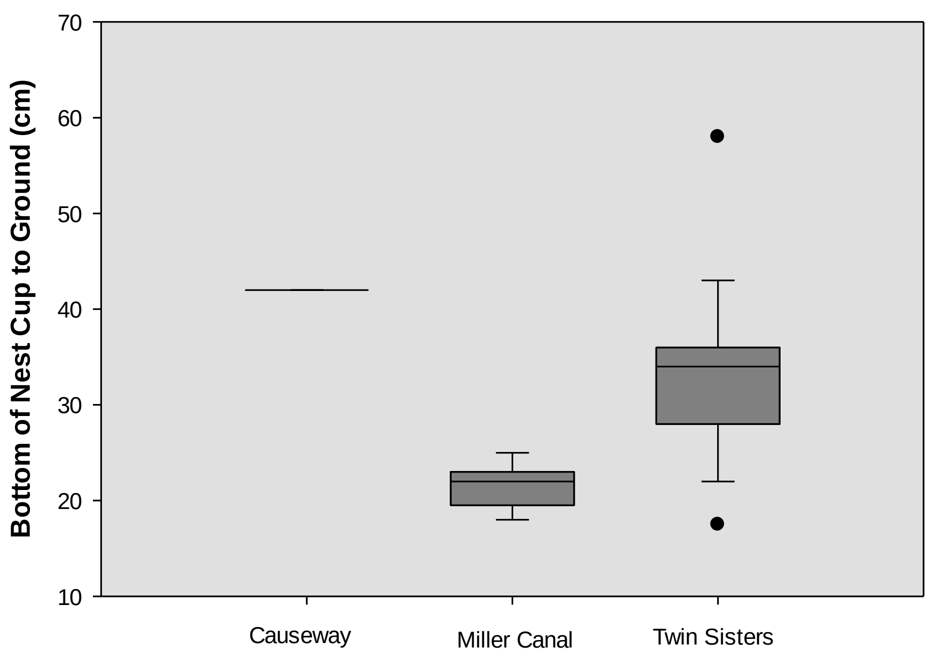


Figure 9: Seaside Sparrow nest heights at three study plots near Georgetown, SC. Only two nests were found at Causeway plot, both of which were 42cm off the ground.

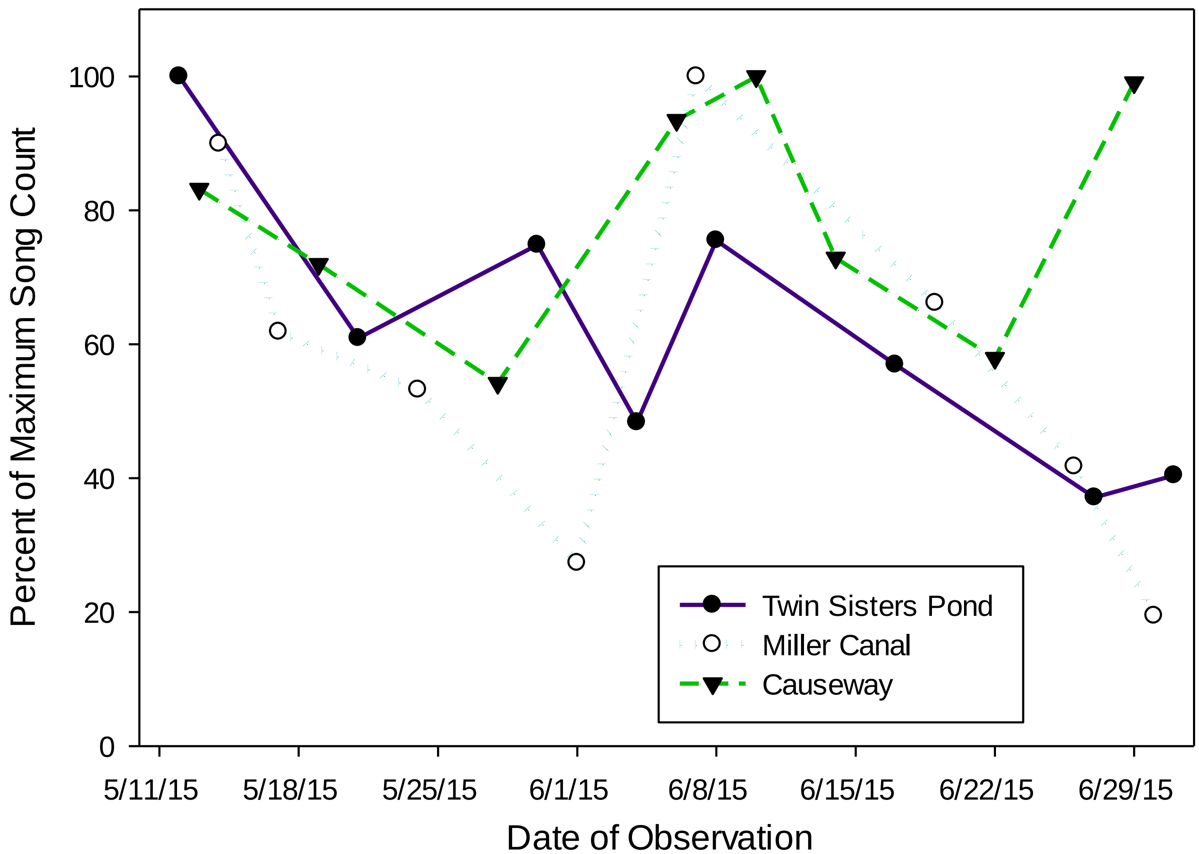


Figure 10: Seaside Sparrow song output between May and July 2015 at 3 plots near Georgetown, SC.

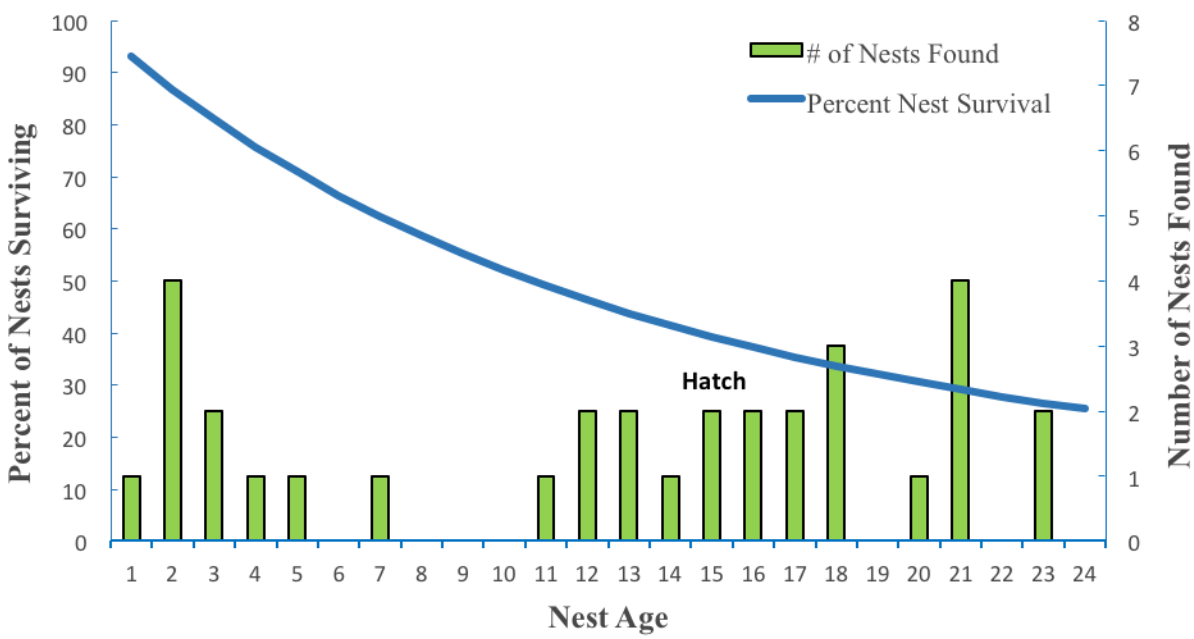


Figure 11: Estimated survival of Seaside Sparrow nests by nest stage and age, and numbers of nests found at each stage near Georgetown, SC